Mitigation of blackouts in PV Grid Connected Distribution Sector

SHORT SYNOPSIS

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Certificate

I hereby declare that the short synopsis *"Mitigation of blackouts in PV Grid Connected Distribution Sector"* being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy In Engineering under faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2018-19

It is a bonafide record of original work carried out under the supervision of Dr Leena G and Dr Mayank Pande and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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ABSTRACT

Now a day due to growing demand, the overloading on a distribution system is becoming a problem which results in frequent blackouts. The most versatile way of tackling the problem is PV grid integration. The P-Q power control can be done from Inverter's side. Methodology adopted will be useful as the mitigation of blackouts can handle very efficiently by the PV inverter in both manmade and natural disaster conditions. The islanding mode operation of the PV system not only gives supply to the emergency loads but also relieves the system from excessive loading which in turn mitigates the blackouts in the system. The blackouts during the last few decades have been studied and the improvement in the correctives measures that were adopted will be dealt with within the constraints. Advantage of PV inverter's control is that when active power demand increases in conventional grid the frequency fall is corrected by the control at generator side which is too far from the load center, but owing to the fantastic property of PV inverters the under frequency compensation can be done at the load side which in turn is fast and power loss is also be minimum.

Key words: DISCOM (Distribution Company) , DG (Distributed generation) , P-Q Power, Blackouts, APC (Active power control), RPC (Reactive power control).

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1. INTRODUCTION

In a densely populated commercial area like Chandani Chowk in Delhi, due to immense increase in demand and space scarcity, the situation of distribution line is very dangerous. The constraints that affect the stability of the system are:

1. Reactive power demand more than supply which results in decrease in system voltage.
2. Active power demand more than supply which results in decrease in frequency.
3. The natural disaster may also lead in blackouts.
4. The manmade disaster is mainly due to point 1 and 2.

There are several other factors which are the causes of blackouts in power system. The critical analysis is done in the field and the main two factors are chosen for the present research work.

Due to limitations of fossil fuels and day by day increasing demand of energy, the convectional sources cannot fulfill energy demand in future. The only way to fulfill and meet out increasing demand of energy is non conventional energy sources. The grid connected PV system is one of the best way to meet out increasing demand of energy and grid inverters will be used to maintain the voltage and frequency profile of the grid during disaster period.

Due to growing demand, the overloading on a distribution system is becoming a problem which results in frequent blackouts. The most versatile way of tackling the problem is PV grid integration. The P-Q power control can be done from the invertor's side. The mitigation of blackouts can be very efficiently and effectively done by the PV inverter in both cases of disaster. The islanding mode operation of the PV system not only gives supply to the emergency loads but also relieves the system from excessive loading which in turn mitigates the blackouts in the system. Advantage of PV invertors control is that when active power demand increases in conventional grid the frequency fall is overcome by the control at generator side which is too far from the load center, but owing to the fantastic property of PV invertors the under frequency compensation can be done at the load side which in turn is fast and power loss is also minimum.

The manmade and natural disasters are the main causes of blackouts. After reviewing the major disasters that occurred throughout the world, a remedial measure will be developed incorporating the magnificent quality of PV inverter which enables the distribution sector not only to get relief from excessive loading both active and reactive but also during blackouts it helps in meeting the requirement of emergency loads.

2. Literature review

In the literature review the papers reviewed are up to 2018. The literature review of past and present research in the area of "Mitigation of blackouts in PV Grid connected Distribution Sector" as voltage rise due to prominent limitation towards useful integration are well dealt in by employing effective and efficient methods (Awad et al. 2008; Demirok et al. 2011). Some aspects are usefully considered to get overall Grid stability: devices operating as compensators and their control management (Lopes et al. 2006)

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2.1 Current Reference Generation (CRG)

In Current Reference Generation control method for reactive power, the required current references will be set up according to the power components that are in power demand as referred in (Bojoi et al. 2011, 2012; Benot et al. 2016).Various control techniques for reactive power in the single-phase inverter are discussed in many papers and reports (Liu et al. 1999, 2011; Prayas Group, 2014; Soultanis & Hatziargyriou, 2007) and direct-quadrature (d-q) transformation is described in (Liu et al. 1999; Sun et al. 2012) papers. The theory of instantaneous reactive power injection may be regarded as the control technique that can be used to produce the two orthogonal current references. A signal integrator is used to monitor and adjust the voltage disturbances. The reactive power control techniques are also suggested in (Tobnaghi, 2016) in the form of DFT and PLL (Zhang et al. 2011).

2.2 V- f control in Distributed Generation

In load variations or disturbances, the system voltage and frequency (V- f) goes beyond the prescribed range (Georgiadis, 2010). To maintain voltage and frequency at required level, the inverters connected with distribution generations are responsible for maintaining voltage and frequency of the system. In past various researches have been done to find out V-f control methods in DGs of Grid connected PV system. In Grid connected PV system voltage and frequency (V-f) control can be done by using traditional droop control methods as described in (Awad et al. 2008; Lopes et al. 2006; Saadat, 2002; Vasquez, 2008). An effective P-Q control technique have been described and discussed in (Pedrasa, 2006).

The traditional concept about control of power (P-Q), fundamental frequency (f) and system voltage (V) at generation side and DISCOM side not at actual customer load side. In micro grid at low voltage, the line resistance (R) is highly greater than line reactance (X), It shows very close relationship voltage and frequency w.r.t to P- Q power as described in many papers (Alben et al. 2009; Baccino et al. 2012; Laaksonen et al. 2005; Sao & Lehn , 2008; Ye Xu et al. 2013). A traditional technique is implemented as described in (Soultanis & Hatziargyriou, 2007).

The scope of renewable energy based DGs are increasing in recent years and published in journal's paper (Tobnaghi et al. 2016).

Hence, the challenges on Mitigation of blackouts in PV Grid connected Distribution Sectors can now more effectively handled. Very few researches have been done regarding voltage and frequency control to mitigate the blackouts in PV grid connected distribution Sector regarding future Challenges and mitigation methods for high photovoltaic penetration (Temitayo et al. 2018).

The rooftop grid integration system design and simulation have been described with the simulation results shown in (Omar & Mahmoud, 2018, 2019) papers. An extensive survey has been done as case study for two major cities in India a report published by Federal Ministry for the Environment (Germany, 2017).

Although in the past the researchers have made extensive efforts towards the harnessing the solar energy for electricity generation but the management of the PV energy is not dealt in efficient way. India being the country which has an ample amount of solar energy throughout the year and interpolating the increasing demand of the electrical energy, a large scope is there to control the energy in a optimized manner. The dense loading on the distribution networks results in blackouts. The research gap is the control of the PV inverter for P-Q control to mitigate the blackouts. The researcher after reviewing a large number of research papers finds a scope in the future for the increase in reliability of the network by the virtue of slight modification in the present PV grid integration system.

The scholar has studied and reviewed the papers on the work done in this field and finds great scope for the research field as not much work has been done across the world to mitigate the blackouts. The blackouts before 1960s were dealt with the old conventional methods as the concept of renewable energy specially solar energy was not much developed. With the new inventions namely the solar power technology the management of the distribution network has become more manageable.

Electricity act 2003 have empowered the three companies to work independently viz: GENCOMS, TANSCOMS AND DISCOMS. Due to the independence of the DISCOMS, it is now possible to control active and reactive power at the distribution side. There are various methods of controlling active and reactive power. There are several successive attempts made towards reactive power control. The conventional approach was placement of fixed capacitors and switched capacitors. This scheme was modified through electronic tuning circuit and implemented as dynamic capacitive tuning of distribution network for smooth voltage control.

For active power control, the conventional method is Brown Bravery and Terrill regulators at generating side. This method is not efficient method as the time delay in transmitting the signal from load center to generating unit is quite high, so this has been further modified through automatic load control and active power control by adjusting PV Grid tied inverters. This approach is further refined and précised

through SCADA to interpolate the excessive active power demand and automatic load shedding. The active power control is to be done at load side. Therefore, entire transmission line is relieved from excessive loading. Under distributed generation highly sophisticated Grid tied PV inverters gives highly sensitive reliable and quick control.

To control active- reactive (P-Q) power a simplified technique to be developed, that suitable to the Indian scenario. For active power control, power transferring angle (δ) and for reactive power control , inject reactive power through placement of capacitance (STATCOM) that will limit the components of Ip=Im Cos θi ,and Iq=Im Sin θi for Vac .

The researcher has studied the work already done in the area and zeroed his research work to mainly mitigation of blackout using STATCOMS and active - reactive (P-Q) power control by PV inverter connected in the roof top PV generation units as these units have been now grid connected, the active-reactive (P-Q) sudden power demands in conventional distribution networks can be easily controlled. A little work has been done in this area in other developed and developing countries. A practical setup of grid connected SPV system of 81 KWp is considered for the practical work.

3. Description of Topic

Due to immense increase in the demand and decrease in supply the chances of blackout is increasing day by day. There is a range of factors responsible for blackouts. Some of the factors are to be considered in the work and selectively the most common factors will be considered for the solution towards the mitigation of the blackout. The Power system is a very vast area viz: generation, transmission and distribution. Owing to the development of the distributed generation and the fact that the most affected area of frequent blackouts is distribution; moreover the work done to mitigate the blackouts can be validated by DISCOM. Due to the aforesaid facts the research area is restricted to the distribution network only. The area of research work will be focused on the active power control to manage the under frequency and over

frequency problem, and reactive power control to manage the voltage profile. The selection of the research topic is justified.

4. Objectives of Research

The research work will be a sincere attempt to find the most efficient measures to mitigate the blackouts in a PV grid connected distribution network and will be focused on the following,

1. To control PV inverter which in fact controls the P-Q power in order to mitigate the blackout will be done in a practical PV grid integrated setup. To test the reliability of the system at all adverse circumstances.

2. To find out the modification in the present conventional rooftop PV grid integration so as to optimize the energy management this will result in mitigation of blackout.
3. To carry out the reactive power compensation by fixed capacitor and switched capacitor.
4. To simulate a 100 KWp PV system using MATLAB and this will be validated with IEEE 33 bus distribution network.
5. To run the proposed scheme in the SCADA controlled distribution network in DELHI as a pilot project.

5. Methodology adopted

The real-time data will be collected from the currently installed PV grid connected system in the distributed system. Simulation will be done in MATLAB and the corrective measures will be applied to the system by the PV inverter control. The artificial condition for the blackouts in the smart grid will be created and the net effect of the control will be analyzed. All the work will be validated on IEEE standard network. An algorithm will be developed for capacitor placement (both fixed and switched).The payback period will be calculated to justify the scheme of capacitor

placement for a real distribution network. An algorithm will be developed for the P-Q power to be controlled through PV inverter for a typical 100 KWp PV grid system The P-Q control of a real distribution network if permitted by local DISCOM will be done and a range of possible ways to mitigate the blackouts will be explored.

6. Expected outcome of the research

The expected outcome of the research considering add interpolating the methodology and after analyzing the work done so far in this research objective is as under:

1. The steps to be taken to mitigate the blackouts in current scenario will be more precise and effective.

2. The cost effective techniques for the active and reactive power control using STATCOMS, fixed and switched capacitor placements and the control by PV invertor will not only relieve the power system from excessive loading but also the reliability will increase.

3. The proposed scheme for the control of PV grid integrated distribution network will stabilize the system and a robust system will be developed which will be immune to the variable frequencies and variable voltage fluctuation which may otherwise lead to the collapse of the network.

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